DEW POINT DISTRIBUTION IN THE CONTIGUOUS UNITED STATES

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ABSTRACT

New maps showing the distribution of average monthly dew points and their standard deviation in the contiguous United States are presented. These are based on recently available summaries of hourly psychrometric data prepared by the U.S. Air Force for approximately 200 stations and on average dew point data prepared by the U.S. Weather Bureau.

1. INTRODUCTION

The accurate representation of the areal distribution of water vapor near the ground has lagged behind representation of other climatic elements. In the United States the standard maps of water vapor distribution in the air near the ground are those of Day [2] published in 1917. Day's maps showed mean 8 a.m. and 8 p.m., 75th meridian time, vapor pressure for January, April, July, and October. They have been included in modified form in more recent publications [10, 12].

New maps showing the distribution of average monthly dew points near the ground in the contiguous United States are presented in figures 2 to 13. These maps are based on recently available summaries of hourly psychrometric data prepared by the U.S. Air Force [11]. Among the several psychrometric elements provided in these summaries are the average monthly dew point and its standard deviation, and the average dew point and its standard deviation for each of eight 3-hr. time groups each month. The availability of the tri-hourly summaries makes possible consideration of the daily range and nature of the diurnal variation of dew point. This aspect of the work will be treated in a separate publication.

Locations of approximately 200 stations in the United States for which psychometric summaries are available are shown in figure 1. Lengths of record average 10 years with most records running from 1949 to 1959, or 1950 to 1960. It would be desirable to have a longer period of record, but a comparison of the Air Force summaries with those of Day did not reveal any systematic changes in the water vapor content of the air near the ground, and the 10-yr. records are judged to be adequate.* It was found that at some sites local sources of water vapor cause higher humidities than those representative of the general station location. This can sometimes be ascertained from consideration of diurnal variation of dew point; in other cases inquiry was made of the Officer-in-Charge of weather stations to determine the representativeness of psychrometric observations. The problem of representativeness of observation sites is most important in dry climates where local sources of moisture must be considered. For example, several stations in the Southwest did not have representative humidity records because they were located over irrigated grass.

In addition to the Air Force summaries, there are other summarized humidity data now available which aid in the delimitation of dew point (or equivalent vapor pressure) distributions in the United States. Average dew points have been computed by the U.S. Weather Bureau [13] for over 200 stations in the United States for the period 1946–1955 for use in evaporation computations. Although the average dew points were determined from 6-hourly observations and are not strictly comparable to the Air Force summaries, their availability makes possible a more comprehensive treatment of dew point distributions, particularly in mountainous areas. Comparison of the Air Force and Weather Bureau summaries again indicates no systematic difference in average dew points for the different periods of record.

2. AVERAGE MONTHLY DEW POINT MAPS

Because of the nonlinear relationship between dew point and saturation vapor pressure, an error is introduced when dew points are averaged directly. This error is a function of the dispersion of the dew points being averaged. Because the standard deviation of the dew point distribution is given in the Air Force summaries, it is possible to estimate the dew point "averaging" error, and the values in the Air Force summaries were corrected for these errors. In general, the errors are less than 1°F. and the distributions on the maps (figs. 2 to 13) are little affected by consideration of the averaging error [4].

Another problem in the preparation of the maps was

*Rantoul, Ill, (Chanute Air Force Base) is the one station in the United States with an Air Force summary for a long period of record which can be compared with a shorter record. At Rantoul the longer summary is for a 25-yr. record of observations each hour from July 1936 to February 1961. The average annual dew point during the 25-yr. record was 0.1°F. lower than the average for a 14-yr. record from 1946 to 1959. The largest differences in monthly averages were found in September (longer average 0.8°F. higher) and December (longer average 1.0°F. lower).

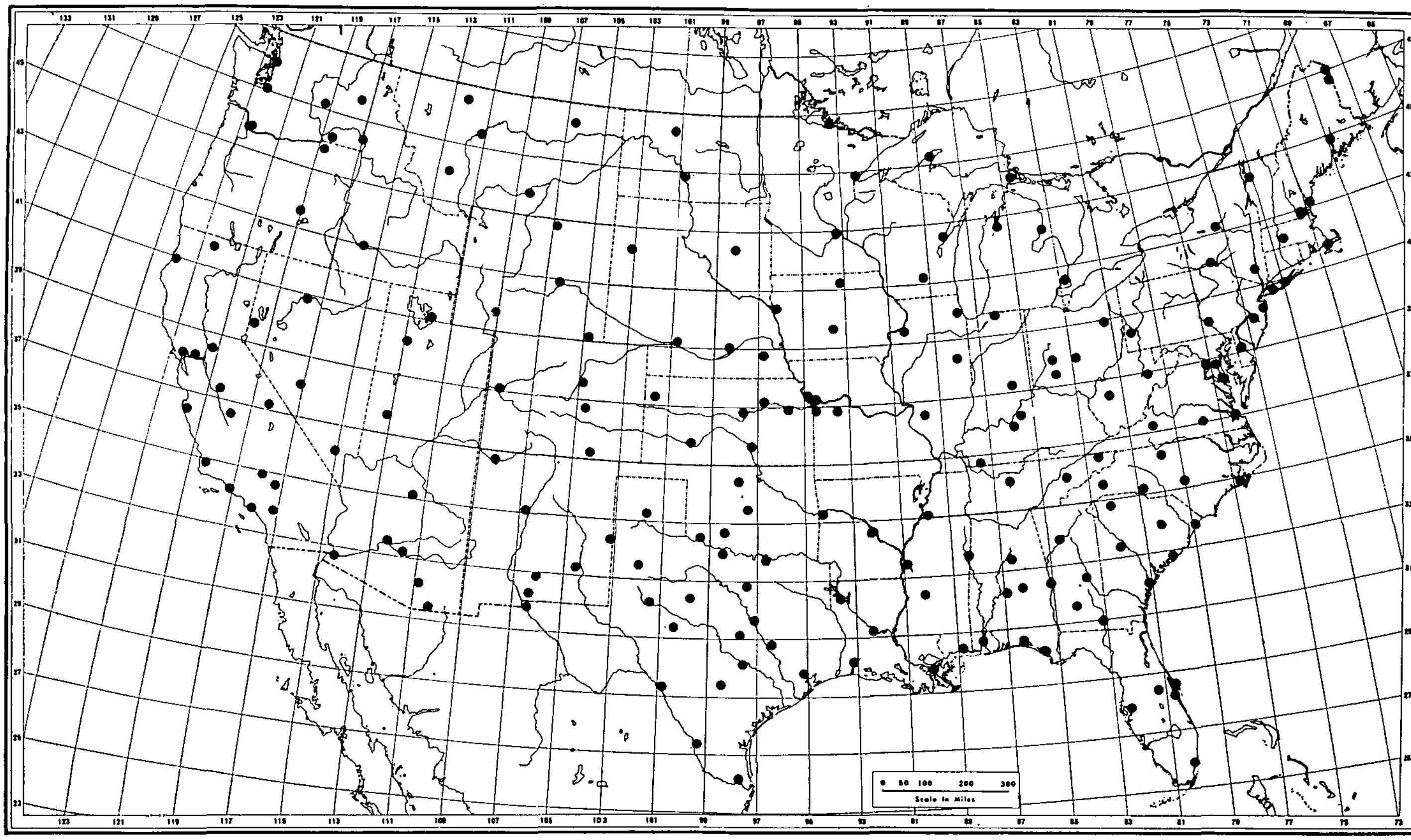


FIGURE 1.—Location of stations for which psychrometric summaries are available.

the question of the reduction to sea level. In general, the practice in North America has been to present maps representing the vapor pressure or dew point near the earth's surface at station elevations [1, 2, 3, 5], while the practice in Europe has been to reduce the data to sea level by appropriate formulae [6, 7, 9]. The maps presented here are not reduced to sea level for two reasons. First, it has been demonstrated that the reduction formulae do not apply where the occurrence of inversions affects the normal decrease of dew point with elevation [8]. Therefore, it is not possible accurately to reduce dew point or vapor pressure to sea level in all cases. Second, for most purposes it is more useful to know the dew point or vapor pressure as it is observed at the station. The amount and distribution of water vapor near the ground is required by such disciplines as hydrology and agronomy, concerned with water balance problems, and physiology concerned with the heat balance of the human body in its environment. Knowledge of water vapor distribution is also needed by design engineers concerned with operation of equipment and degradation of material. In each of these cases the information required is for the station elevation and not for a theoretical sea level.

The placement of the lines of equal dew point (isodrosotherms) in figures 2 to 13 in much of the country is fairly well defined by the data. In the mountainous areas, however, it is more difficult to represent the average patterns of dew point. To aid in the interpretation of the data in mountainous areas, graphs of average monthly dew point versus elevation were prepared. Several of the graphs are shown in figure 14 to illustrate the dew point change with elevation. Dew points at intermediate levels between station elevations can be checked on the graphs as an aid in plotting the isodrosotherms in mountainous areas.

An interesting feature of figure 14 is the seasonal reversal in dew point lapse rate between Reno, Nev., and Blue Canyon, Calif., In summer the primary source of water vapor in this area is from the southeast, associated with the influx of air from the Gulf of Mexico. Most of the year the moisture source is from the west. Blue Canyon, 40 mi. west of Reno, has lower average dew points than Reno in summer, but most of the year Blue Canyon has higher average dew points than Reno even though it is at a higher elevation.

On a very broad scale the patterns of the isopleths on the maps reflect the prevailing controls of water vapor near the ground. East of the Rocky Mountains the east-west alignment of the isopleths reflects the dominant latitudinal or temperature control, in the Mountain States the isopleths are more irregular and reflect dominant altitudinal control; while in the Far West the alignment of the isopleths parallel to the coast demonstrates the dominant control of exposure to the Pacific Ocean.

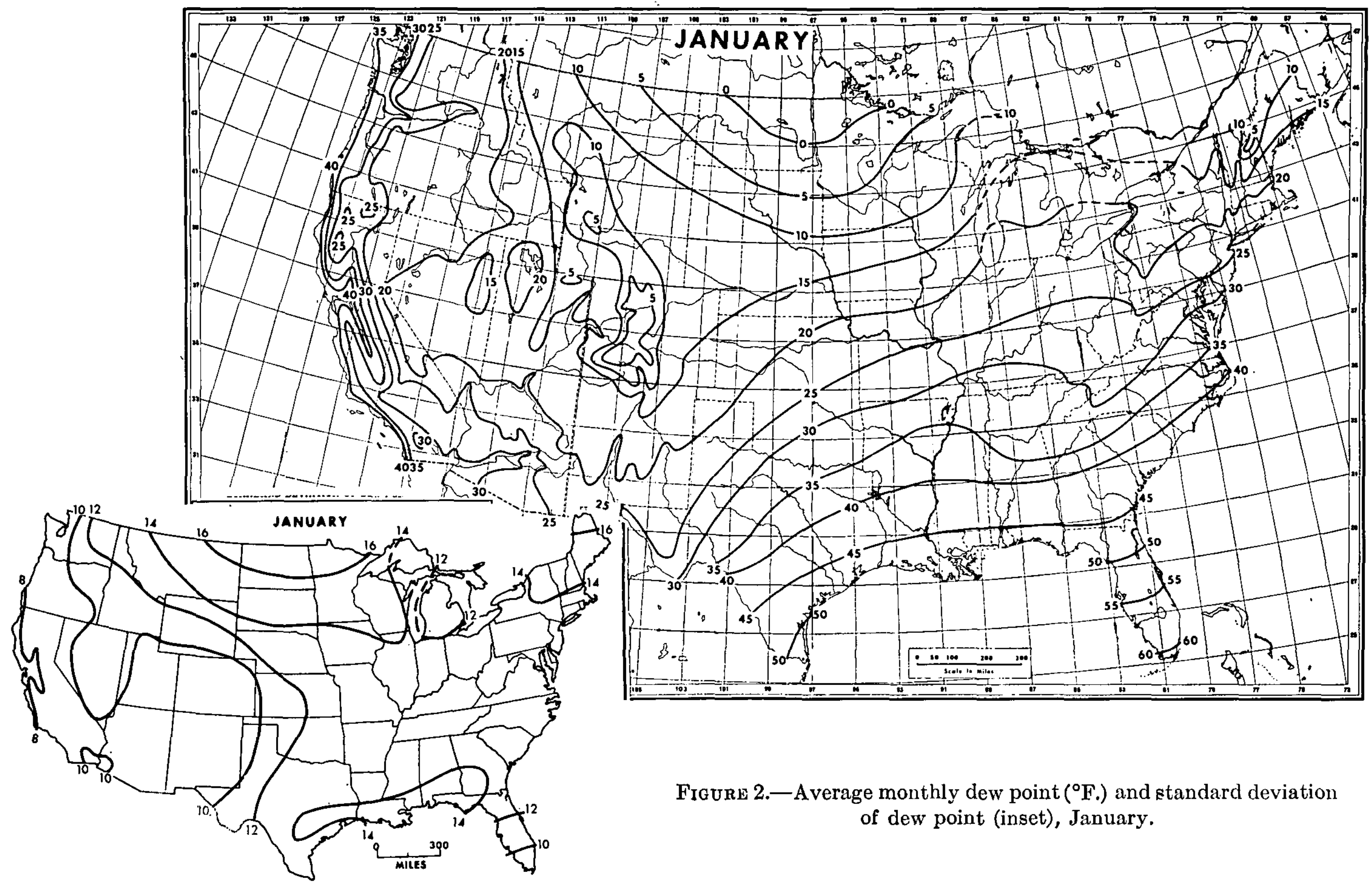


FIGURE 2.—Average monthly dew point (°F.) and standard deviation of dew point (inset), January.

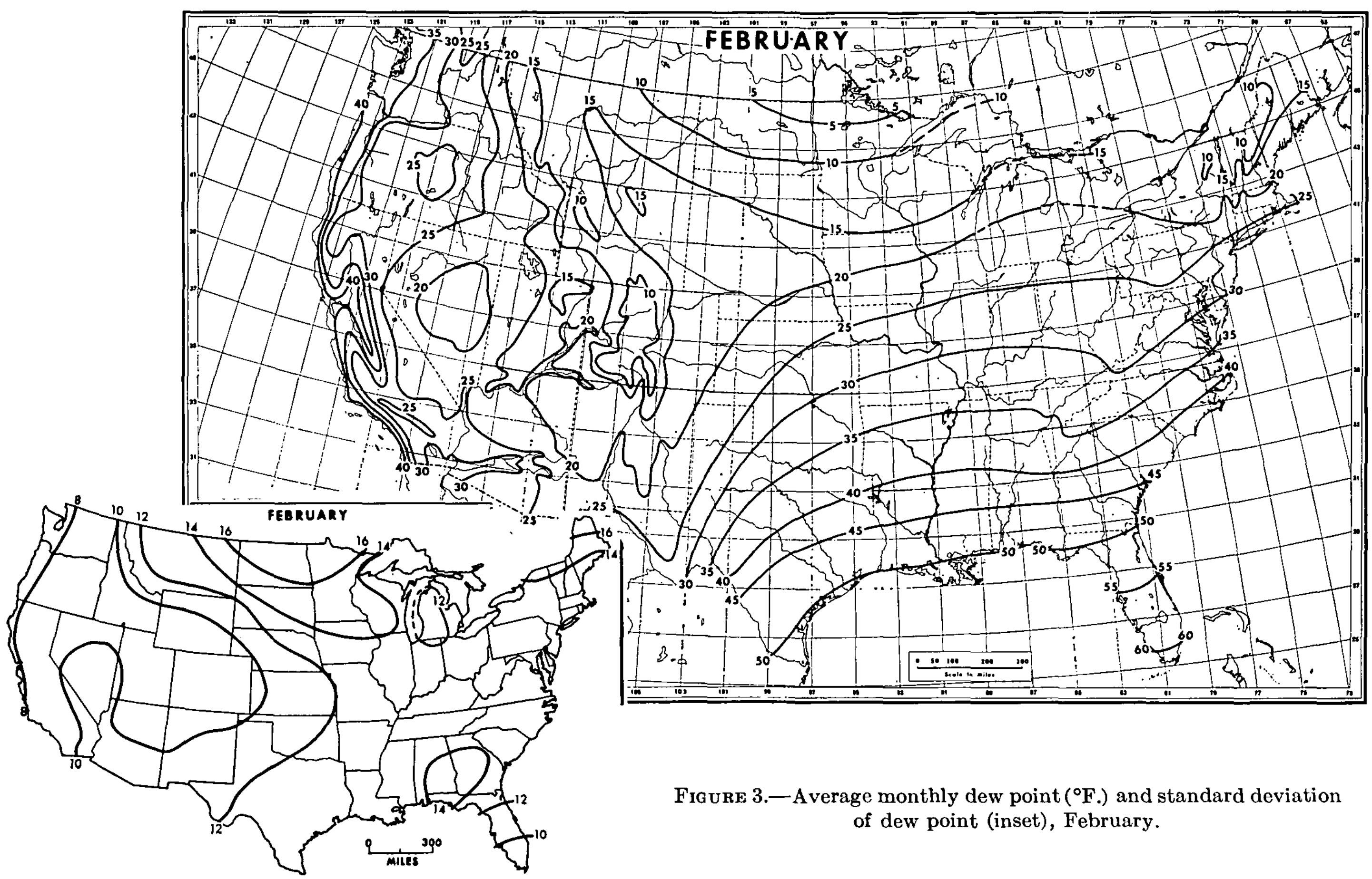
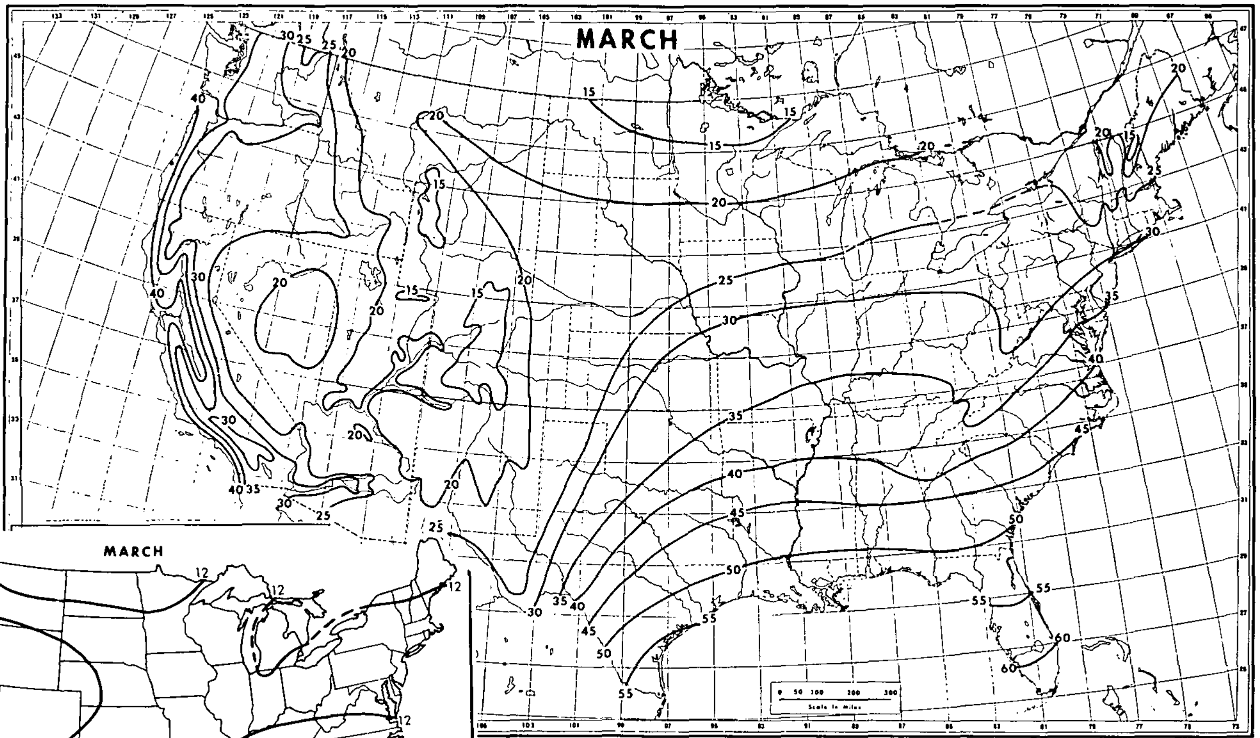


FIGURE 3.—Average monthly dew point (°F.) and standard deviation of dew point (inset), February.



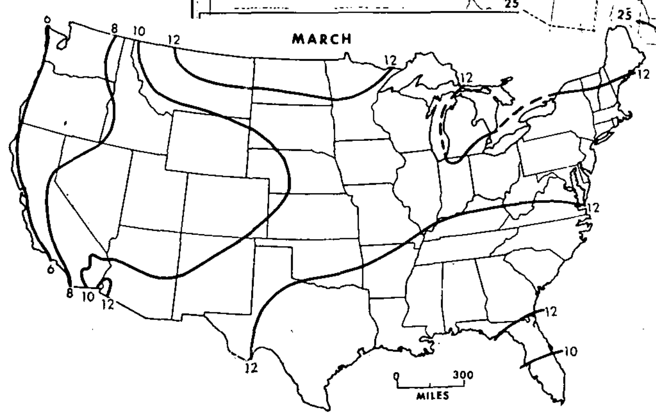
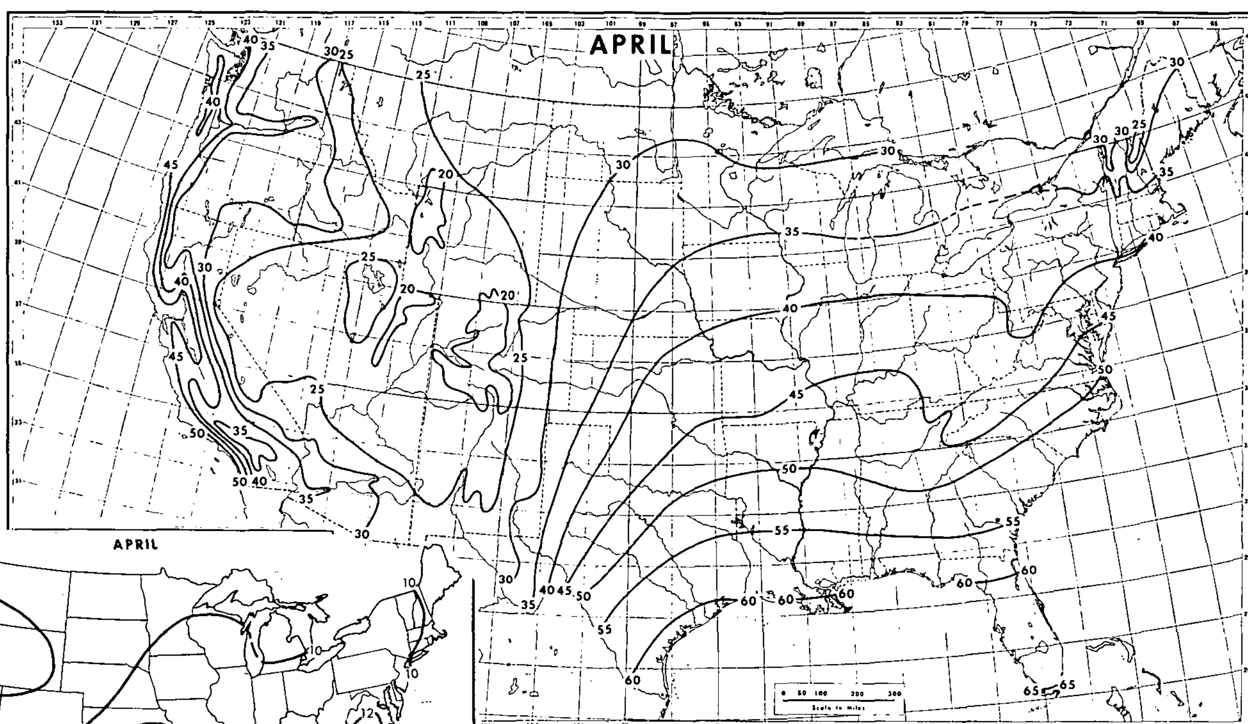


FIGURE 4.—Average monthly dew point (°F.) and standard deviation of dew point (inset), March.



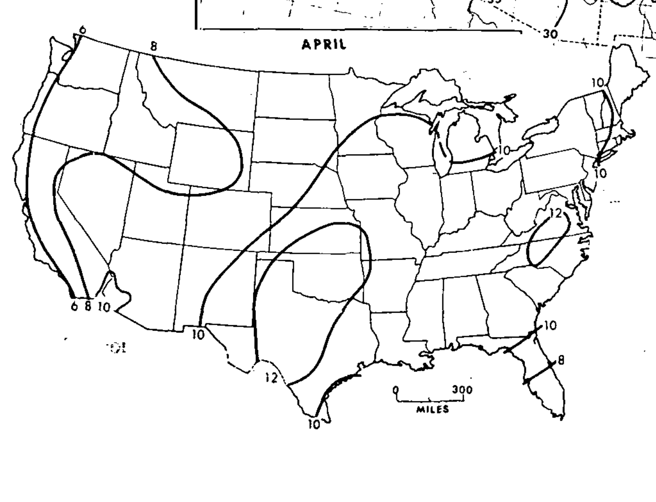


FIGURE 5.—Average monthly dew point (°F.) and standard deviation of dew point (inset), April.

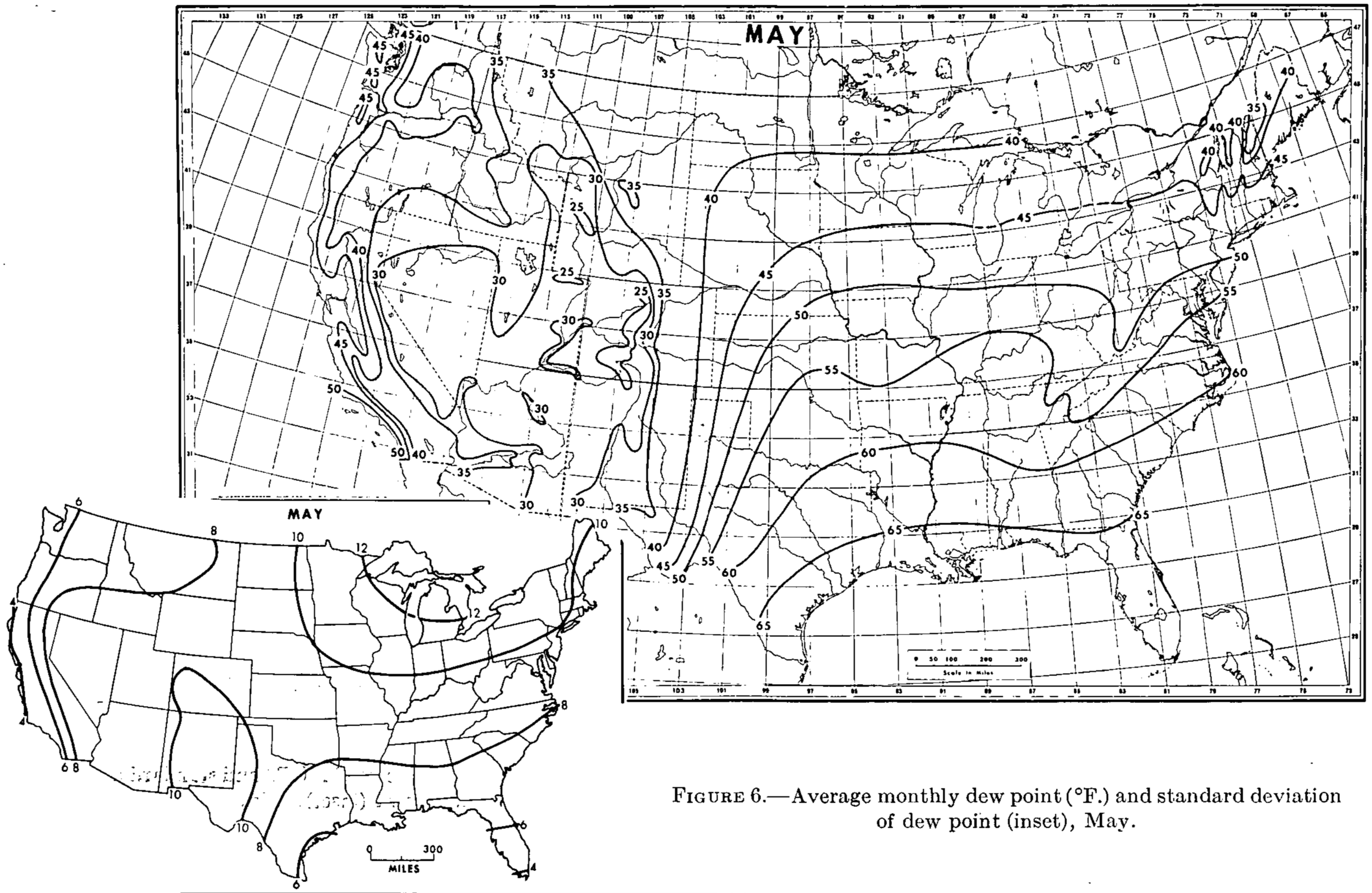


FIGURE 6.—Average monthly dew point (°F.) and standard deviation of dew point (inset), May.

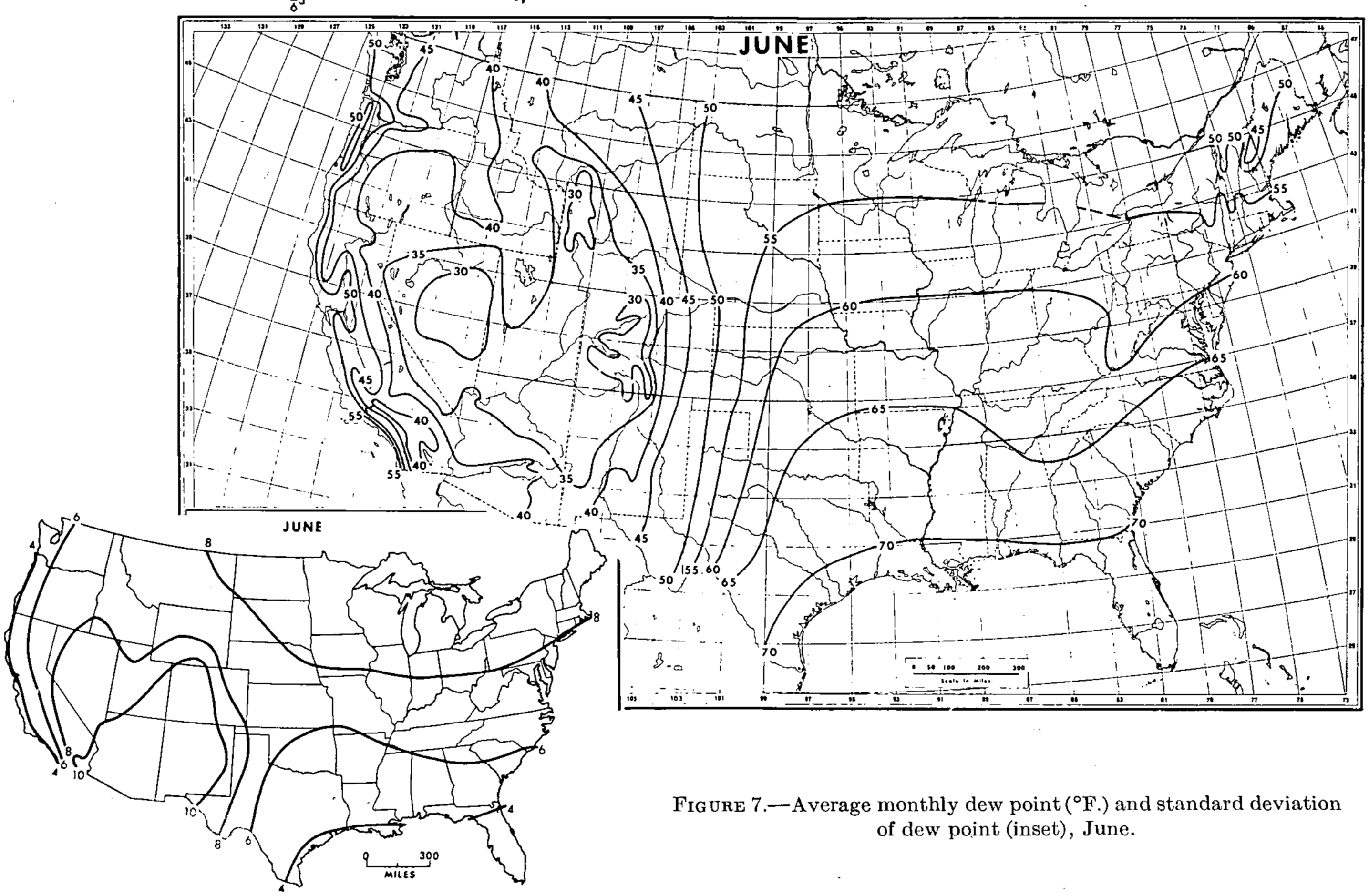
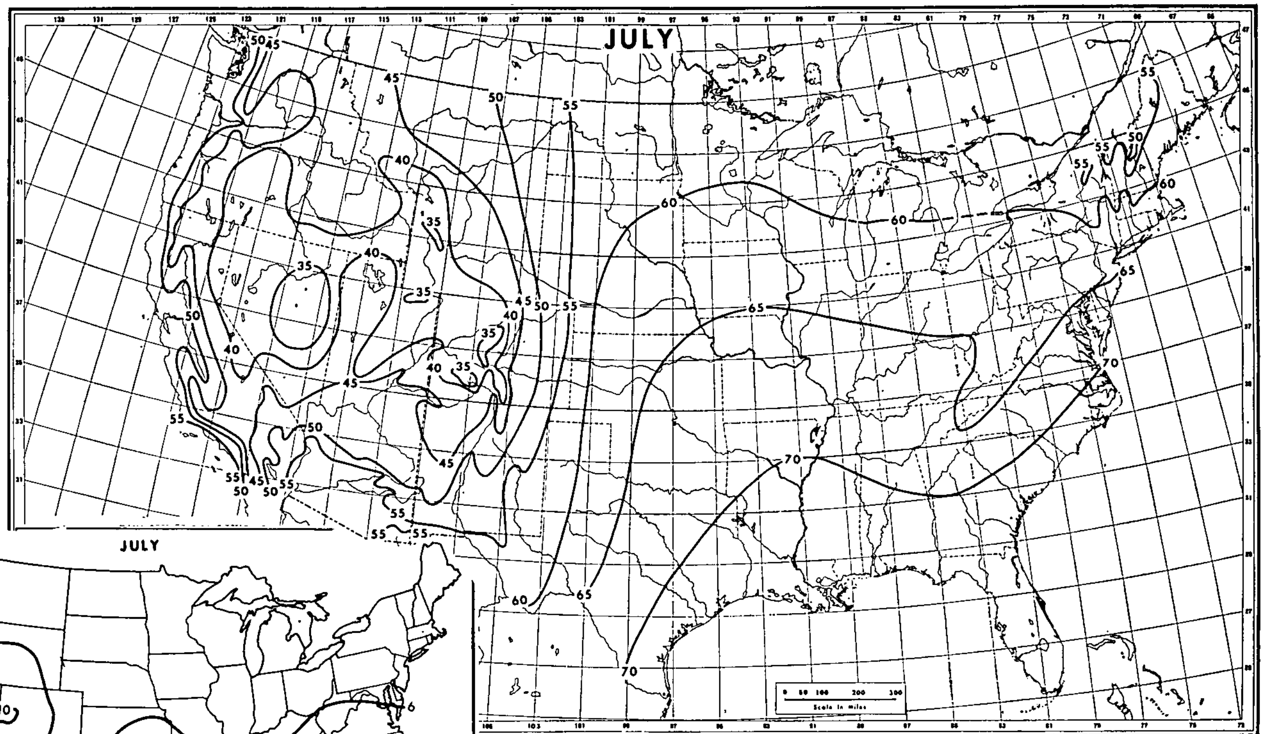


FIGURE 7.—Average monthly dew point (°F.) and standard deviation of dew point (inset), June.



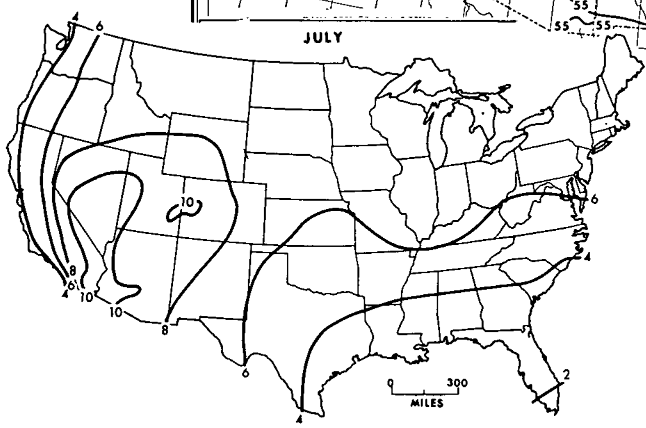
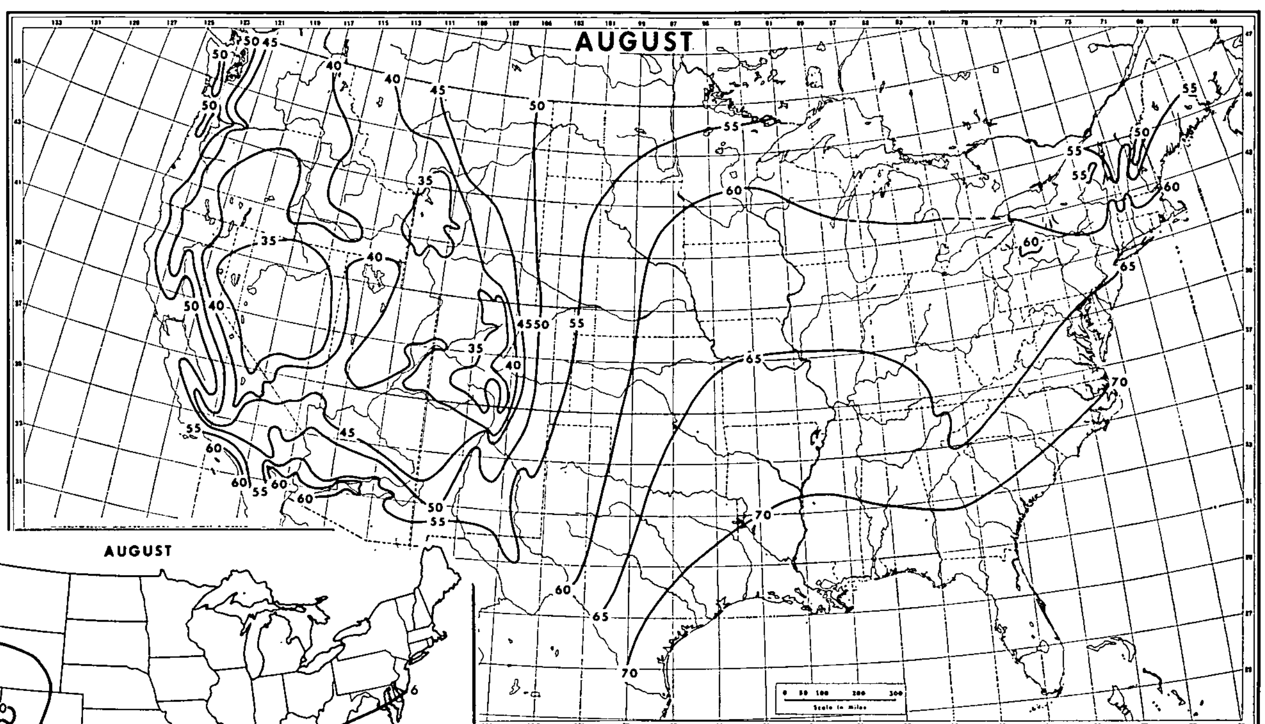


FIGURE 8.—Average monthly dew point (°F.) and standard deviation of dew point (inset), July.



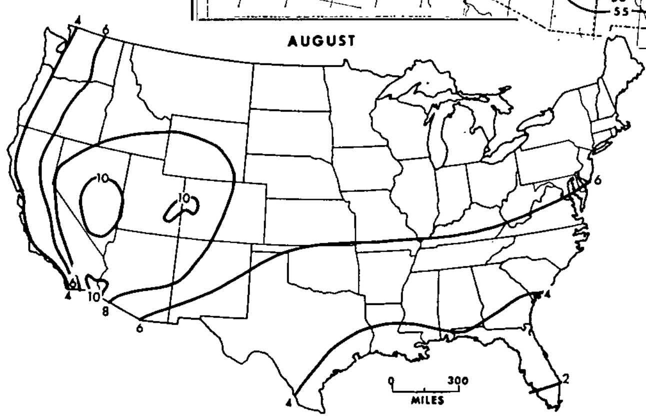


FIGURE 9.—Average monthly dew point (°F.) and standard deviation of dew point (inset), August.

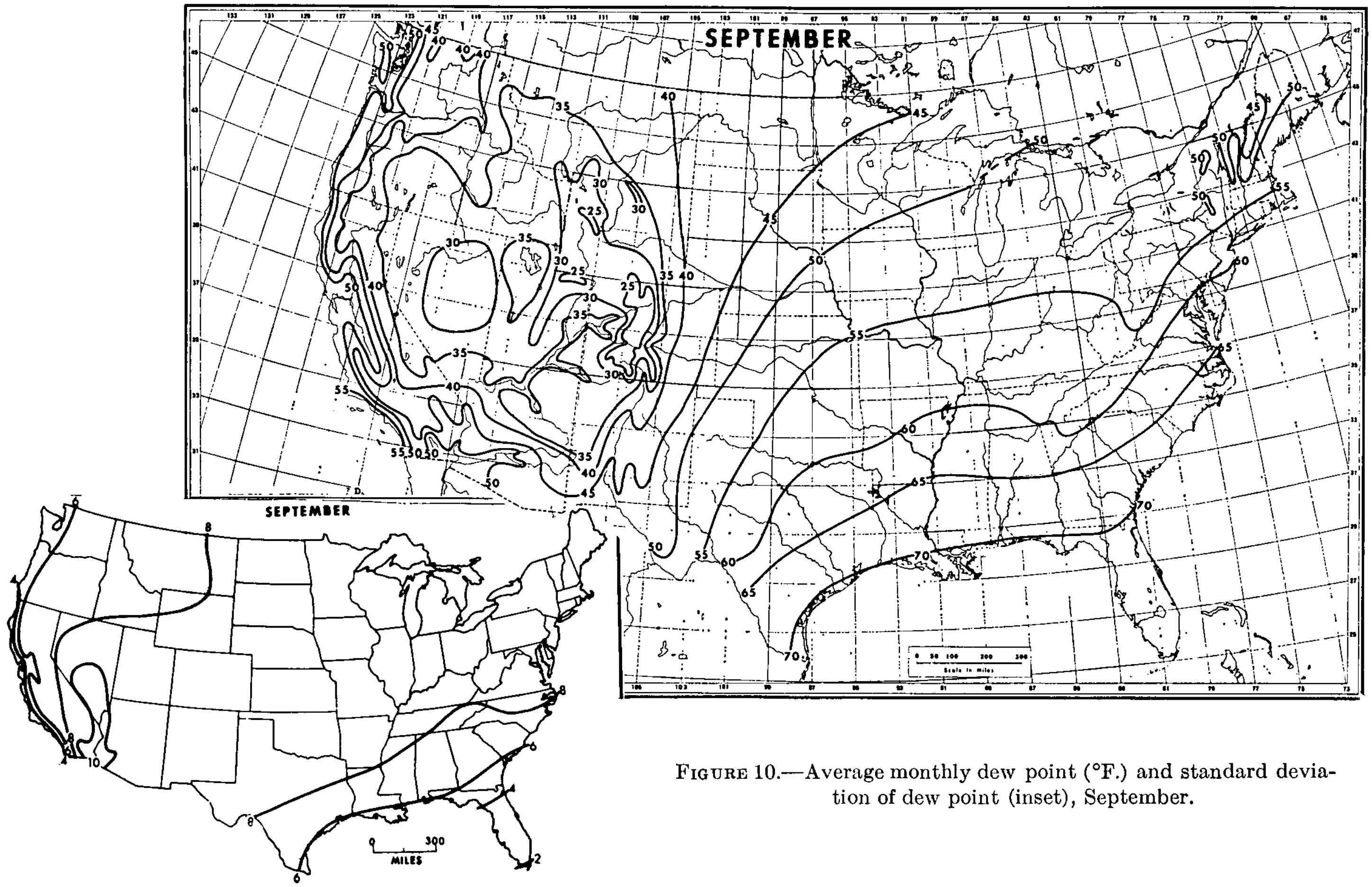


FIGURE 10.—Average monthly dew point (°F.) and standard deviation of dew point (inset), September.

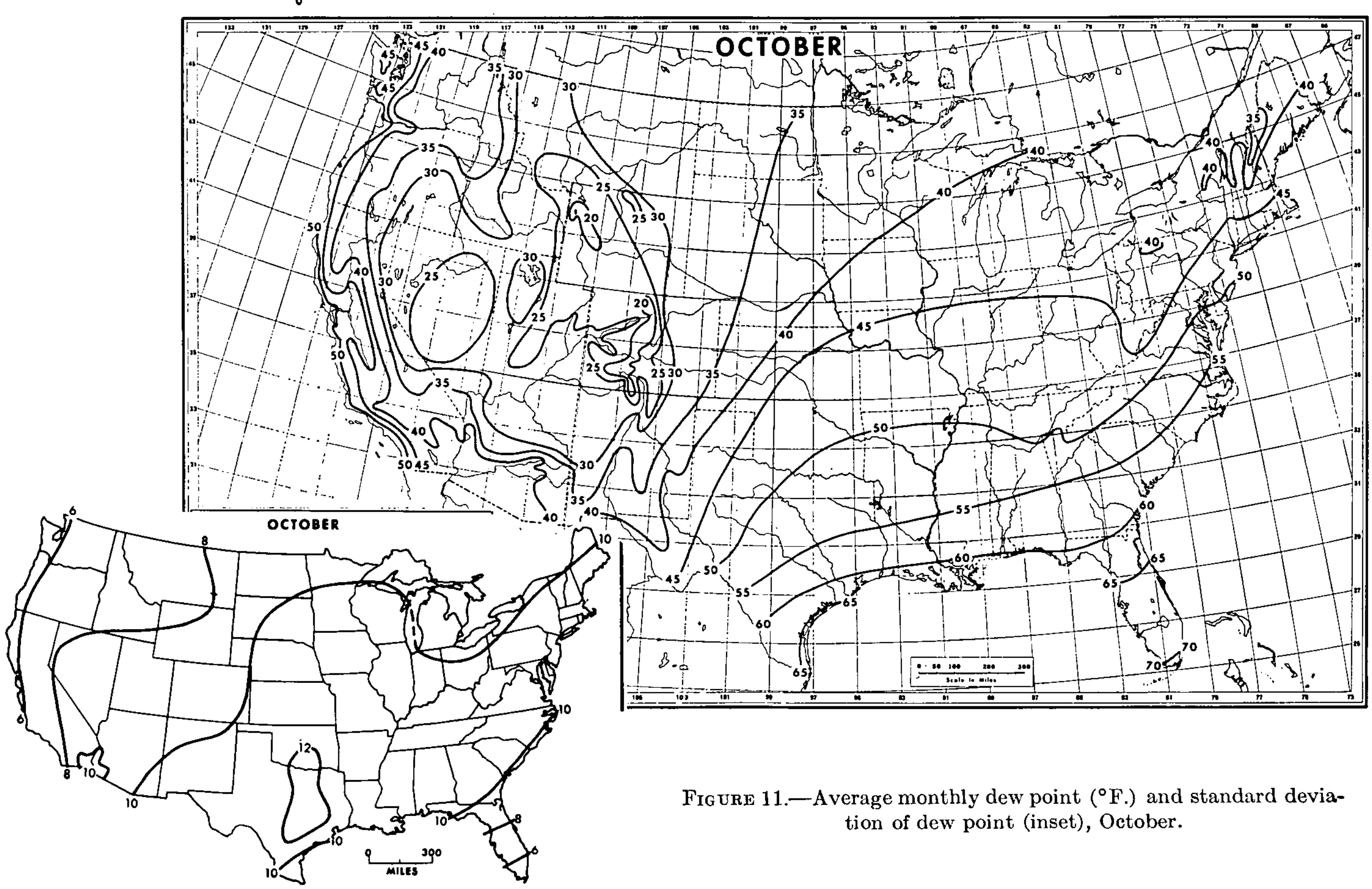


FIGURE 11.—Average monthly dew point (°F.) and standard deviation of dew point (inset), October.

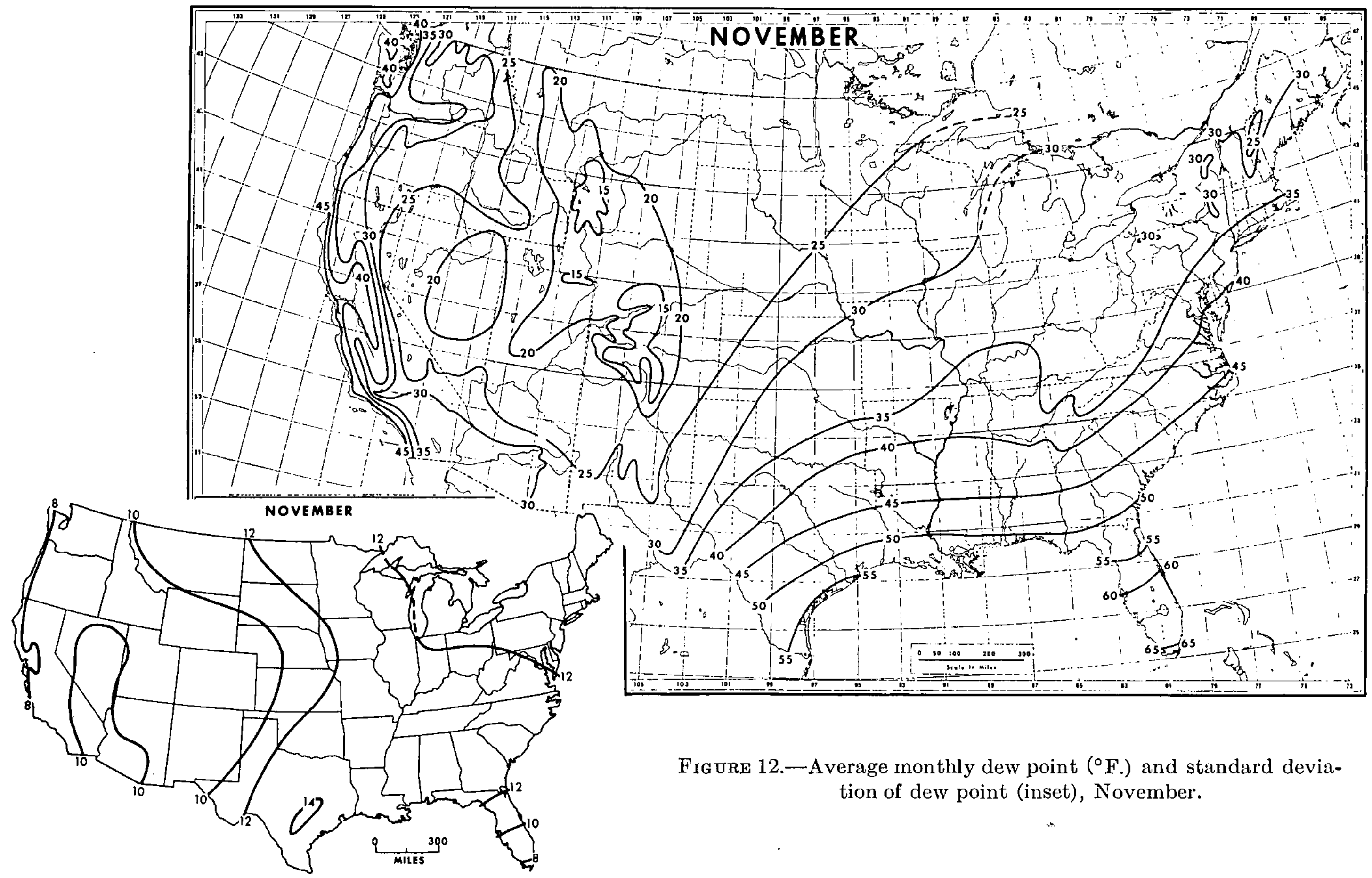


FIGURE 12.—Average monthly dew point (°F.) and standard deviation of dew point (inset), November.

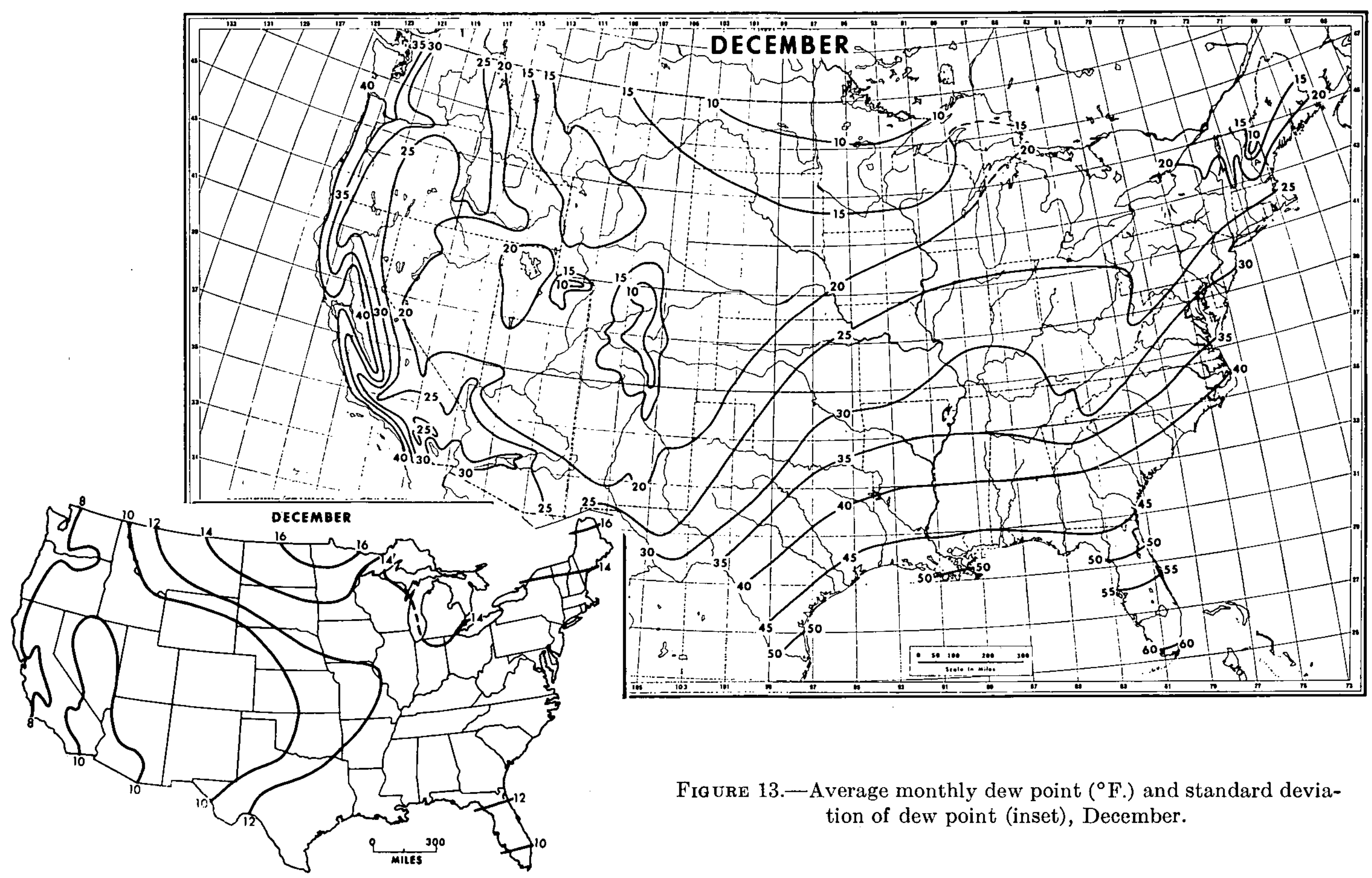


FIGURE 13.—Average monthly dew point (°F.) and standard deviation of dew point (inset), December.

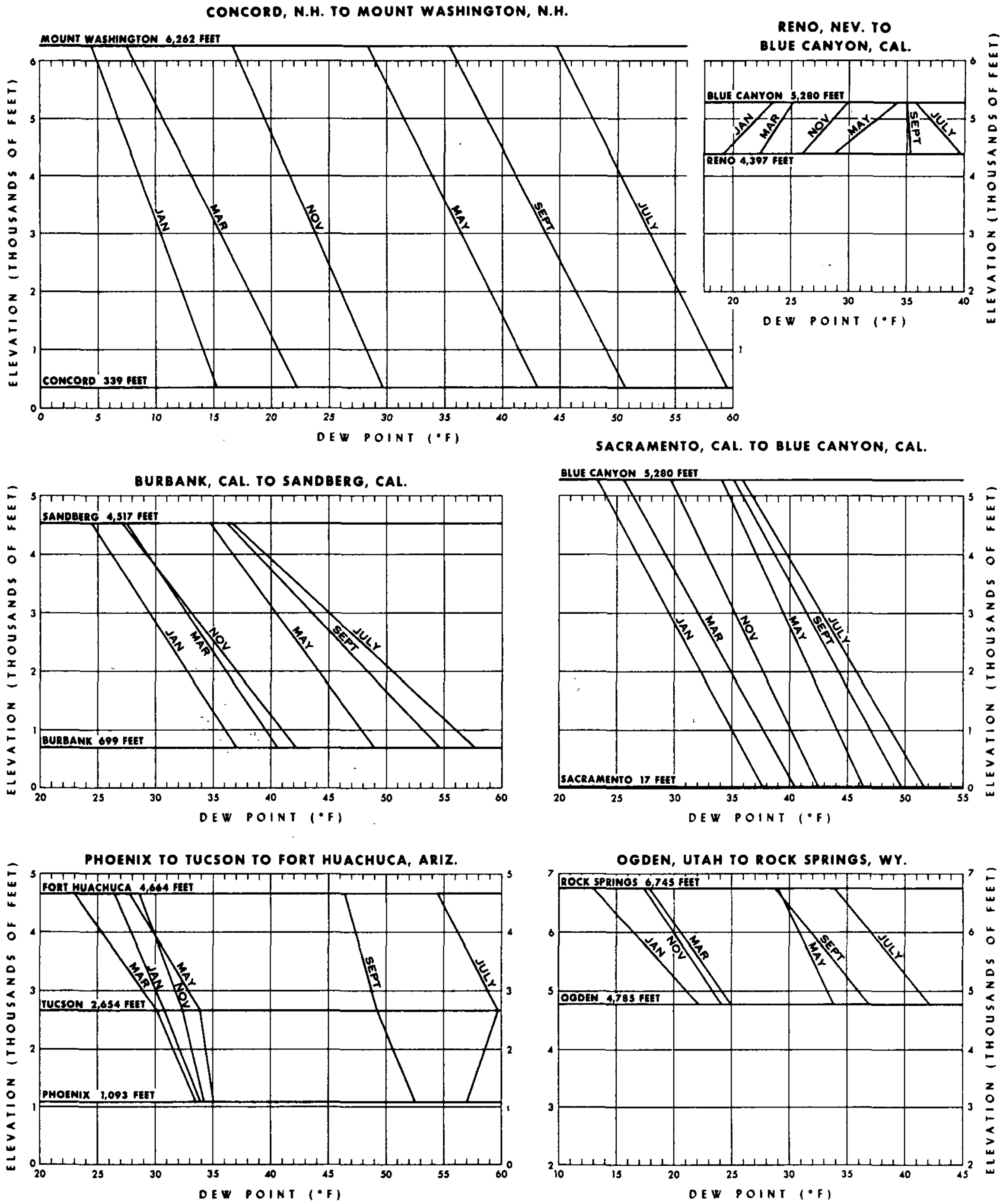


FIGURE 14.—Dew point change with elevation in six selected areas of the United States.

A number of factors must be considered in the interpretation of the standard deviation patterns shown in inset maps to the average monthly dew point maps. Standard deviations of dew points are larger where air mass changes are frequent. A second factor which increases the dispersion of the dew point distribution is the diurnal range in dew point. Obviously, standard deviations of monthly dew point distribution will be larger where diurnal ranges are larger. Diurnal ranges in dew point vary from about 1° F. in the summer months in the South to as much as 10° F. in the very cold areas in the winter. A third factor affecting the standard deviation of the dew point distribution is the nature of the dew point itself. The amount of water vapor involved in a given dew point change increases as the dew point increases. Twelve times as much water vapor is involved in a dew point change from 70° to 75° F. as from 0° to 5° F. Other things being equal, it would be expected that larger diurnal variations and standard deviations of dew point would be associated with lower dew points, and this is the case.

ACKNOWLEDGMENTS

This study is part of the author's Doctoral Dissertation at Boston University [4] and appreciation is expressed to Professors Robert Batchelder and Howard Hirt, Boston University Geographers, for their guidance and helpful suggestions. Thanks are also due personnel of the U.S. Army Natick Laboratories who aided in the study. In particular, the work of Leonora Kundla in preparing the data for machine computation, and of Aubrey Greenwald, Pernel Leuvelink and James Murphy, for cartography, are recognized.

Data for the study were obtained from the USAF Air Weather Service Climatic Center, and the U.S. Weather Bureau Hydrologic Services Division. Without the cooperation of the personnel of these agencies, this study could not have been undertaken.

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[Received August 6, 1964]